Name _____

Chi-Square Introduction

The Situation

As the wife of a huge baseball fan, I end up attending numerous Pirates games. Each game, my husband tries to win more tickets by spinning a prize wheel. In recent years, the Pirates have upgraded from a non-electronic wheel to an electronic version. Since this change, it seems like he has been winning free tickets less, causing us to wonder if the contest is now "rigged." How many people should we expect to win before we decide a factor other than chance is involved in the contest? As a scientist, I decided to perform a statistical test to find out.

The Investigation

After examining the prize wheel one day, I found that, of the 18 slots, 3 awarded free tickets. To get an ample sample size, I watched 90 people spin the wheel and only 9 won tickets.

- Of those 90 people, how many would you expect (if only chance was involved) to win free tickets?
    - 3 / 18 = ? / 90 ? = _____

Would you expect foul play if only 14 won? What about 13? 12? At what point do you decide something other than chance is involved? That is where a chi-square test becomes a valuable tool. This statistical test is used to compare observed data with data we would expect to obtain according to a specific hypothesis. It helps scientists determine what results are significant versus those that are due simply to chance.

Writing your Hypotheses

The chi-square test is always testing what scientists call the **null hypothesis**, which states that *there is no significant difference between the expected and observed results*. Thus, any difference is due to chance. In contrast, the **alternative hypothesis** is what we are attempting to demonstrate in an indirect way by the use of our hypothesis test. It is a prediction that there IS a measurable interaction between variables.

If the null hypothesis is rejected, then we accept the alternative hypothesis. If the null hypothesis is not rejected, then we do not accept the alternative hypothesis.

- Write the null hypothesis for our investigation below:
    -
        -
- Write the alternative hypothesis for our investigation below:
    -
        -

Formalize your Thinking

Before you start plugging numbers into the chi-square formula, make a "contingency box" to formalize your thinking.

	Winner	Loser
Expected		
Observed		

Using the Chi-Square Formula

$$\chi^2 = \sum \frac{(\text{Observed Value} - \text{Expected Value})^2}{(\text{Expected Value})}$$

Chi-Square **summation**

Plug the numbers from your contingency box into the formula above to calculate your chi-square value

$$\chi^2 = \frac{(\quad - \quad)^2}{(\quad)} + \frac{(\quad - \quad)^2}{(\quad)}$$

Using the Chi-Square Table

In order to determine the significance of your chi-square value, you need to compare it to the chi-square critical value.

- First you need to calculate the degrees of freedom.
  - Degrees of freedom (df) = n – 1
    - n is the number of categories (or number of possible outcomes)
  - In our problem, we have 2 categories (win or lose) so our df = 2 – 1 = ____
- Next, determine the chi-square critical value
  - We typically use a p-value, or confidence interval, of 0.05, meaning that we would expect any deviation to be due to chance alone 5% of the time or less
    - Note: Drug companies may need a smaller p-value of 0.01, allowing for even less deviation due to chance
  - Our critical value for this experiment therefore would be _____

Chi-Square Table – Critical Values

	Probability				
Degrees of Freedom	**0.9**	**0.5**	**0.1**	**0.05**	**0.01**
1	0.02	0.46	2.71	**3.84**	6.64
2	0.21	1.39	4.61	5.99	9.21
3	0.58	2.37	6.25	7.82	11.35
4	1.06	3.36	7.78	9.49	13.28
5	1.61	4.35	9.24	11.07	15.09

Drawing your Conclusion

- If the calculated chi-square value is less than the critical value from the table, then we **accept** (or fail to reject) the null hypothesis
    - If we accept the null hypothesis, it means we have a 95% confidence level that there is NO statistically significant difference between our observed numbers and our expected numbers
    - In other words, the differences between the observed and expected are probably due to chance alone
- If the calculated chi-square value is greater than or equal to the critical value from the table, then the null hypothesis is **rejected**
    - If we reject the null hypothesis, we are saying the differences between the observed and expected numbers are probably due to something other than chance alone
    - Thus we are accepting our alternative hypothesis
        - Note: This does NOT mean we "proved" an alternative to chance

- Our calculated chi-square value = _____

- Our critical chi-square value = _____

- Our calculated chi-square value is _____ than our critical chi-square value
- Therefore, we _____ our null hypothesis which means
    -
    -

*What if 8 of the 90 people spinning the wheel had won free tickets?

- Write your null hypothesis
  -
    -
- Write your alternative hypothesis
  -
    -
- Formalize your thinking by making a contingency box

- Calculate your chi-square value
  - Show your work:
  - Chi-square value =
- Determine the critical chi-square value
  -
- Draw your conclusion
  - Our calculated chi-square value is _____ than our critical chi-square value
  - Therefore, we _____ our null hypothesis which means
    -